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Licensing Strategies of the Entreprising – But Vulnerable – "Intellectual property" Vendors

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Abstract:
This paper investigates in an exploratory manner the licensing strategies pursued by firms whose business model is based on developing and licensing out their intellectual property rights (IPRs). These are not traditional suppliers, since they do not engage in production or commercialization, but focus solely on invention. While considerable anecdotal evidence exists about these IP vendors, there has been no systematic investigation of how they use licensing to appropriate value from their investments in R&D. In this paper, we suggest that the licensing strategies they pursue can be differentiated along two main dimensions: whether the driving force behind the inventive process is "technology push" or "market pull", and the degree to which the innovative activities carried out by the IP vendor are mutually dependent upon the innovative activities of the other relevant market players. On this basis, four main licensing strategies are identified. We investigate the relative benefits and costs of these four strategies, and the factors affecting licensing choices.

Key words: Intellectual property, licensing, strategy
JEL Codes: O31, O32, O34

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1. Introduction

Traditionally, firms used intellectual property rights to provide the legal basis for their strategies to invent, develop, manufacture and market new products and processes. By temporarily excluding others from exploiting the invention, they bought time to see whether or not the invention had commercial potential, and if so, how best to develop it and appropriate the associated benefits. Today, a growing number of firms specialize solely in the generation of ideas. These new "intellectual property" (IP) vendors may be defined as firms whose business model is based on generating intellectual property *per se* and then selling or licensing the rights to others. Such firms cannot be characterized as traditional suppliers, since they do not engage in production or commercialization. They focus instead on the invention stage, and their contributions to the knowledge economy are purely intangible. They can be seen as the "R&D" part of the supply chain, and their licensees as the "buyers" of their ideas, in the further commercialization process.[1] This paper investigates, in an exploratory manner, the licensing choices faced by IP vendors, and how these licensing strategies affect their efforts to profit from their investments in R&D.

We seek to contribute to several related streams of literature. These include work on the determinants of technology licensing (e.g. Arora and Fosfuri, 2003, Arora, 1995, Caves *et al.*, 1983, Choi, 2000, Contractor, 1981), the strategic use of licenses (e.g. Grindley and Teece, 1997, Kollmer and Dowling, 2004), intellectual property rights and firm boundaries (Arora and Merges, 2004, Gambardella, 2005, Hagedoorn, 2003), and innovation strategies in the market for ideas (e.g. Arora *et al.*, 2001, Boldrin and Levine, 2006, Gans and Stern, 2003, Teece, 1998).[2] While considerable anecdotal evidence exists about IP vendors, there has to my knowledge been no systematic investigation of the licensing strategies they pursue.

[1] Our definition does not include companies that specialize in one area and license out complementary proprietary technologies developed for their own use (such as Proctor & Gamble's decision to license out its proprietary computer simulation software for plastic bottles to Stress Engineering Services Inc, a package engineering consulting firm (*Plastics Technology*, 2005). It is also important to differentiate our use of the term "IP vendor" from, for example, the law firm that helps companies manage their IP and prevent the theft of their ideas, or the venture capital firm that helps a fledgling start-up company leverage its IP.

[2] Coase (1974) also discusses the "market for ideas," but in the context of an analysis of the economics of the First Amendment of the U.S. Constitution.

In this paper, we suggest that licensing strategies can be differentiated along two main dimensions: whether the driving force behind the inventive process is “technology push” or “market pull” (e.g. Mowery and Rosenberg, 1979), and the degree to which the innovative activities carried out by the IP vendor are mutually dependent upon the innovative activities of the other relevant market players. The first dimension concerns whether or not the IP vendor develops the technology for its own sake (because it feels the technology itself has promise), or whether the vendor acts in response to a well-defined, known market need. As regards the second, licensing strategies involving technologies where firms are mutually dependent on access to each other’s technology will have a substantially different dynamic than licensing strategies where firms can fashion their R&D programs relatively independently of each other.

On this basis, four main licensing strategies are identified: (1) The *visionary* strategy: Developing a potentially valuable invention “for its own sake” – which might be of interest to other firms – and then licensing it out (this represents the combination of the dimensions technology push-low mutual dependence); (2) The *contributor* strategy: Developing a potentially valuable invention which other firms must license if they are to continue with their own product development programs (technology push-high mutual dependence); (3) The *directed* strategy: Entering into an exclusive licensing agreement to develop an invention in response to a specific customer need (market pull-low mutual dependence); and (4) The *expansionary* strategy: Developing an invention in close cooperation with other firms and engaging in extensive reciprocal knowledge sharing and cross-licensing (market pull-high mutual dependence).

Specializing in generating valuable ideas for new products and processes *per se* can be both rewarding and challenging. Because an idea is more easily modified than a physical product, it can often be applied in more than one manner. As a result, many IP vendors can build on their patented inventions, and license out a stream of further inventions. But “commercial success” can be difficult to define, since these vendors do not market their inventions.

To survive and prosper, IP providers must be able to appropriate sufficient returns from their investments in inventive activity. They may fear that potential licensees will be tempted to expropriate technologies revealed to them. Thus puts them under enormous pressure both to

protect their new ideas effectively, and to continue to be innovative, and find new customers. They are also dependent on external sources for all of their revenues. Some are financed by academic grants, others obtain seed capital from government agencies, others rely on venture capital and/or bank loans, or partner agreements. To the degree that it is difficult to estimate the value of an idea, it may be problematic for them to raise capital. Whatever the case, the IP provider constantly risks being squeezed out, if problems arise in its own research program (as is the case for the vendor that pursues Strategies 1 and 2), or if its partners' priorities change (Strategies 3 and 4). This paper investigates the special characteristics of these creative, enterprising, but highly vulnerable firms.

The paper is organized as follows. Section 2 explores the theoretical background for our arguments. Section 3 sets forth the differentiating features of IP vendors' licensing choices, and outlines the four main strategies they can pursue. Section 4 discusses the challenges they face, and the relative benefits and costs of the four strategies. Section 5 asks: How can we define "commercial success" for an IP provider? Section 6 concludes.

2. Theoretical background

A license contract provides the legal basis for a continuing relationship between patentee and licensee, where the two parties work together to maximize their mutual profit. In contrast to selling to the patent rights to another firm, the licensor retains ownership of the technology, and can thereby exert control over its manufacture and sales (Nanayakkara, 2002). Licenses can take the form of exclusive licenses, non-exclusive licenses, or cross-licenses. Cross licenses are used for technologies where many firms hold patents on key aspects of the technology (Grindley and Teece, 1997). The different parties cross-license the rights of their patented inventions to each other to ensure access to the technologies they need for their own product development, thereby avoiding the possibility of mutually blocking patents.

Licensing is said to work best if the costs of replicating and transferring the technology are relatively low, and the costs of imitation relatively high. This occurs when the knowledge concerned can be codified, is not context-specific, and where intellectual property rights can be reasonably well defined and enforced (Arora *et al.*, 2001, Williamson, 1991). Firms may

license out patented technology if they are not interested in entering the market themselves, or lack the resources to do so. Licenses can enable the exchange of knowledge, facilitate entry into foreign markets, or bring tax benefits.

In the economics and strategy literature on technology licensing, the key early studies were Contractor (1981), and Caves *et al*. (1983), who examined the reasons for the high transaction costs associated they entailed due to the complexity of the subject matter to be transferred, along with the risks attributable to small numbers bargaining, asymmetric information, the uncertainties of innovation, and the difficulties of contracting for knowledge given its "public good" characteristics. Related analyses (e.g. Atuahene-Gima, 1992, Yoshikawa, 2003) analyzed the costs and benefits of technology licensing versus other organizational forms, such as in-house R&D or joint ventures. Other work has explored ways to deal with problems associated with licensing through the design of the contract (e.g. Arora, 1995, Choi, 2000, Larson and Anderson, 1994, Macho-Stadler *et al*., 1996, Williamson, 1996).

Key to the theoretical basis of this paper is Teece's seminal work (1986) on who captures the returns from investments in R&D. Teece maintained that in weak appropriability regimes, it was often the owners of specialized complementary assets that earned the lion's share of the profits, and not the original inventor. Only firms operating in strong appropriability regimes should engage in licensing. Other scholars have noted the benefits of collaborative agreements (Hagedoorn, 2003, Klevorick *et al.*, 1995, Kollmer and Dowling, 2004). Even Teece, in later writings (1998), came to recognize the potential advantages of cooperation.

Theoretical interest in the market for ideas is grounded in the rising importance of the role of intangible assets as sources of competitive advantage (e.g, Granstrand, 1999, 2000, Teece, 2000). The last decades of the twentieth century witnessed a rapid growth in arrangements for the exchange of new products or services, particularly in high-tech industries, including R&D joint ventures, licensing, and R&D contracting. Earlier, the communication of ideas required proximity and specialized channels to customers, suppliers, and distributors. Today, with the new information and communications technologies, information can be fed to international multifunctional teams cooperating to develop new products (Teece, 1998). Markets for ideas increase the "strategy space": firms can choose to produce the knowledge internally, acquire it

from external sources, or outsource their own knowledge to other firms (Arora *et al.*, 2001). Start-up innovators recognize that it is not enough to have a good invention. What matters is to link firm strategy to the commercialization environment to determine how best to translate an idea into an invention valued by customers (Gans and Stern, 2003).

The relationship between the strength of intellectual property rights and firm boundaries was recently investigated by Arora and Merges (2004). They argue that if small technology specialist suppliers possess important new information valuable to the potential buyer, and have strong patent protection on their inventions, this increases their bargaining power in contractual negotiations with larger firms. A key implication of their analysis is that specialized suppliers with strong firm capabilities in innovation should be encouraged to invest in them. This article led to a lively debate on the role of IPRs. Gambardella (2005), for example, contends that while strong IPR protection may favor the division of labor between specialized independent suppliers and larger firms, patents can also have negative effects. One is that they raise the incentive to use patents strategically to prevent others from using the invention. In this paper, we proposed to take the insights of this literature and the debate over the role of intellectual property rights one step further: to investigate how firms that specialize solely in the production of ideas can use licenses strategically.

Some studies focus on related strategic aspects of technology licensing. Scholars have examined the role of licenses in the strategic exploitation of intellectual property rights (e.g. Davis, 2004, Kollmer and Dowling, 2004, Rivette and Kline, 2000), industry differences in the uses of licenses and the incentives to license (e.g. Bessy *et al.*, 2002, Young, 2005), and the function of licenses in specific sectors (e.g. Grindley and Teece, 1997, Guilhon *et al.*, 2004, Cohen *et al.*, 2000). Hagedoorn (2003) analyzes joint patenting by companies. Yet none of these scholars confront the special problems and opportunities faced by firms specializing *solely* in the creation and licensing of IP.

An investigation of IP vendors can add a new angle to this broader theoretical discussion. First, it shifts the focus of analysis characteristic of many studies from the choices confronting the *buyers* of ideas to the choices confronting the *sellers*. Second, we are interested not in why firms choose between licensing and internalization (e.g. Williamson, 1985), but in how firms

use licensing for strategic advantage. Third, since IP vendors do not engage in production, the problems associated with capturing value from ideas become especially acute. These vendors can only secure appropriability in the context of a license agreement. Appropriability mechanisms like lead time, complementary sales/service, and complementary manufacturing (Cohen *et al.,* 2000), that can be used by firms which both invent and commercialize new products, are not available to them. Thus the problems associated with the "public good" nature of knowledge (Arrow, 1962) may pose a critical challenge.

Several recent trends have contributed to a fertile growth environment for IP vendors. Many large companies have found it necessary to cut costs by reducing R&D staff and in-house laboratory capabilities. This creates an increased need to acquire intellectual property developed by other firms (e.g. Klevorick *et al.*, 1995), particularly in science-based industries (e.g. Gambardella, 1995). Related to this has been the trend towards increased specialization, pressing companies to define where their core competencies lie and to find external partners for non-core technologies (e.g. Leonard-Barton, 1992).

3. Four licensing strategies

3.1. Distinctive features of IP licensing choices

What factors underpin the licensing strategies of IP vendors? We propose that these choices can be differentiated along two main dimensions. The first concerns the driving force behind the inventive process. In the literature on firm innovation strategies, a distinction is made between "technology push" and "market pull" approaches (for a review, see Mowery and Rosenberg, 1979). This distinction is important to our arguments because it goes to the notion of intent: What motivates these firms to specialize in the generation of ideas? The driving force behind technology push innovation is that the firm has a good idea "for its own sake", develops the idea even though it is not clear what the demand is, and then tries to sell it. This approach enables the firm to leverage its core competencies, and gives its R&D staff greater say in defining what they feel would be an important area of innovation. The main risk, of course, is that there will not be a market for the good when it is offered for sale or licensing.

The driving force behind market pull innovation is that the innovator becomes aware of a specific customer need, searches for a way to fill it, and develops the product or service on that basis. One implication is that the scientists and engineers who work for such firms must be willing to adjust their own research agendas to what the marketing staff find important. On the other hand, they can be more certain than their colleagues at a technology push IP firm that the invention will find a buyer.

A second critical dimension of the licensing choice concerns the degree to which the research activities of the IP provider and its potential licensees are mutually dependent on each other. Key to understanding this dimension is the concept of the "cumulativeness" of the technological regime within which these firms operate (Scotchmer, 1991). A technology may be characterized as "cumulative" when a given innovation gives rise to a stream of interlinked improvement innovations, or lays the basis for improvements in related areas (e.g. Breschi *et al.*, 2002, Merges and Nelson, 1994). When seen in the context of the IP vendor's licensing decision, what is important is the degree to which the firms concerned find themselves "forced" to cooperate and enter into license agreements with each other, since they require access to other firms' technologies to carry out their own R&D activities.

In technological regimes characterized by high cumulativeness, such as computers, semiconductors, and electronic equipment, manufacturers typically hold the rights to technologies both they – and others – need, leading to extensive cross-licensing (Grindley and Teece, 1997, Hall and Ham, 2001). For such technologies, the main function of patents is to serve as "bargaining chips", enabling mutual access and the orderly division of rights. For example, as described by Grindley and Teece (1997), in the early years of the development of radio technology, the leading firms held patents in inventions so important to the others that technological progress in this industry was deadlocked. Only with the formation of the Radio Corporation of America was the problem solved. Today, firms realize they have no choice but to cross-license their patents to each other.

Technological regimes of low cumulativeness, like the pharmaceutical industry, have a different dynamic (Malerba and Orsenigo, 2002). After a company successfully develops one drug, it basically starts all over again to search for promising new molecules. With the

revolution in biotechnology, these conditions changed somewhat, since small biotech firms have been able to search more efficiently for new molecules, focusing on specific segments of the search space. But their buyers (the large pharmaceutical firms) can still pick and choose among different candidates. For non-cumulative technologies, the main function of patents is to give firms exclusive rights over their inventions. Licensing serves primarily to transfer the rights from one party to another. But the parties are not critically dependent on access to each others' technologies to continue with their own research activities.

On this basis, we suggest, four IP licensing strategies may be identified (see Figure 1).

Figure 1: Four licensing strategies

Driving force Degree of mutual dependence	Technology push	Market pull
Low	(1) The *visionary* strategy: Developing a potentially valuable invention "for its own sake" – which might be of interest to other firms – and then licensing it out <u>Examples of IP vendors:</u> Orbital Engine Corporation Ultra-Scan Mohave Aerospace ventures Therex	(3) The *directed* strategy: Entering into an exclusive licensing agreement to develop an invention in response to a specific customer need <u>Examples of IP vendors:</u> The early Genentech Virexx Medical NeuroSearch
High	(2) The *contributor* strategy: Developing a potentially valuable invention which other firms must license if they are to continue with their own product development programs <u>Examples of IP vendors:</u> Systemonic NTP MercExchange	4) The *expansionary* strategy: Developing an invention in close cooperation with other firms and engaging in extensive reciprocal knowledge sharing and cross-licensing. <u>Examples of IP vendors:</u> ARM Quallcomm Cambridge Display Technologies

3.2. Four licensing strategies

(1) The *visionary* strategy (technology push-low mutual dependence): Developing a potentially valuable invention "for its own sake" – which might be of interest to other firms – and then licensing it out

Companies that pursue this strategy invent a product or process without a specific customer need in mind, and then license it out. A case in point is the Australian-based Orbital Engine Corporation (OEC), which invented an environmentally friendly fuel injection system for 2-stroke engines. OEC patented the basic invention and a stream of related inventions, licensing out the rights on a non-exclusive basis to the major automakers and other engine manufacturers. The company charged extremely high royalties for its licenses (automakers had to pay $30-40 per engine, as opposed to the industry rate of about $1), both to ensure that the automobile manufacturers took the technology seriously, but also, not least, to enhance its earnings (Morkel and Willoughby, 1992).

A second example is Ultra-Scan, which introduced the world's first ultrasonic fingerprint scanner in 1996. Ultra-Scan holds a number of key patents relating to the use of ultrasonics in reading, matching and identifying fingerprints. The technology can be applied in uses ranging from airport security systems and fraud protection to biometric smart cards and online account access. Ultra-Scan seeks to establish ultrasound as the dominant biometric technology and the global standard for fingerprint identification (Williams, 2002b, http://ultra-scan.com).

Other visionary IP vendors enter into exclusive licensing agreements. The California-based Mohave Aerospace Ventures (MAV) developed a reusable rocket that can carry passengers to the edge of the earth's atmosphere and back. In 2005, Sir Richard Branson announced that Virgin Group had contracted to license the technology, with the aim of launching a new era of space tourism (Davis and Davis, 2006, *The Economist,* 2004). The same applies for inventions created by university scholars in non-cumulative technologies. An example is Therex, a spin-off company founded by three University of Buffalo professors who had invented and patented an anti-bacterial compound. Therex licensed out the rights to a pharmaceutical manufacturer to further develop and test its invention (Wappman, 2002, Williams, 2002a).

Finally, this category includes some of the notorious "patent trolls." These are firms that patent potentially valuable inventions but do not commercially develop them themselves, or initially license out the rights. Later, if they discover that another firm has used their technology, they can demand license fees or another form of compensation. Firms subject to such suits may try to buy off the patent holder by agreeing to a monetary settlement, or paying license fees. One of the earliest trolls was Jerome Lemelson, an independent inventor with master's degrees in both aeronautical and industrial engineering, who began to apply for patents in the 1950s. Eventually he received 562 U.S. patents, making him the most prolific inventor since Thomas Edison.[3] If he felt a company was infringing one of his patents, he sued. One of his inventions was a toy race car track including vertical loops. In 1989, a U.S. federal jury ordered Mattel Inc., developer of the Hot Wheels toy car racing system, to compensate Lemelson for patent infringement (www.spectrum.ieee.org).

(2) The *contributor* strategy (technology push-high mutual dependence): Developing a potentially valuable invention which other firms must license if they are to continue with their own product development programs

Here, the IP firm leverages its patent(s) to create value because other firms working in related areas cannot proceed without gaining access to the technology. Here, in contrast to Strategy 1 (where potential buyers may or may not decide to license the technology), buyers have no choice. If they require access to the IP vendor's invention, and fail to do so, they must completely revamp their product development activities, or go out of business.

Contributor IP vendors typically work in the areas of software and electronics. Many are small, entrepreneurial ventures (including university spin-offs). A case in point is Systemonic, a wireless chip company founded in Germany in 1999 by Gerhard Fettweis, professor of mobile telecommunications at the Technical University of Dresden. Fettweis had built up an expertise in digital signal processors (DSPs), a special chip critical to communications

[3] Lemelson took patents in a wide range of technologies, in a range of technologies, from automated manufacturing systems to bar code readers to video cameras to facsimile machines. Beginning in the 1970s, he brought patent infringement suits against a number of major U.S. corporations including General Motors, IBM, General Electric and Zenith, reportedly reaping hundreds of millions of dollars in royalties and court awards (Columbia and Blasberg, 2006).

applications. Systemonic licensed its intellectual property to the large telecommunications and consumer electronics companies (Campbell, 2000).

This category also includes a number of “patent trolls.” But there is an important difference between visionary and contributor trolls. Visionary trolls can force a company to stop manufacturing a particular item (as illustrated the toy racing car track mentioned above). But unlike contributor trolls, they do not threaten the company’s entire product development program. In recent years, the most prominent troll cases have concerned Internet business methods. Not only has there been a proliferation of patents on Internet business methods, but many are also of questionable validity (Davis, 2006).

Virginia-based NTP Inc., for example, launched a patent infringement lawsuit against the Canadian firm Research in Motion Inc. (RIM), manufacturer of the BlackBerry wireless communication devices. NTP had obtained five patents on inventions in e-mail systems with wireless networks but did not develop the technology itself. RIM claimed it had had no idea it was infringing these patents. The case went through several court hearings, where the validity of NTP’s patents was questioned but never resolved. Finally, threatened with the possible discontinuation of its U.S. operations (home to more than 3 million BlackBerry users), RIM agreed to give NTP $612.5 million as a one-time payment covering the lifetime of the disputed patents (Heinzl, 2006, Nuttall and Waters, 2006, Yang *et al.,* 2005). A second example is MercExchange, a small online vendor which received three patents related to the process of online auctions and shopping in 2000 and 2001, and later brought suit against eBay for violating them. In 2005, a U.S. appeals court ruled that eBay had willfully infringed one of MercExchange’s patents. EBay would either have to stop using it, find a new way to do it, or license MercExchange’s patent. EBay fought back, taking the case to the Supreme Court, which should rule in late 2006 (Puzzanghera, 2006, Soat, 2005).

(3) The *directed* strategy (market pull-low mutual dependency: Entering into an exclusive licensing agreement to develop an invention in response to a specific customer need

Here, the IP firm seeks to fill the specified demand of a customer. Knowledge sharing and customer feedback are crucial. The two parties are dependent on each other in the context of the specific license arrangement, but their innovative activities more generally are not dependent on continued access to each other's technologies, as is the case for Strategies 2 and 4. This strategy is exemplified by the early Genentech. In the initial years of biotechnology, the pharmaceutical corporation Eli Lilly, the dominant incumbent supplier of beef and pig insulin, sponsored three separate teams to carry out research to express the insulin gene, which was necessary for the commercial development of human insulin. Two teams consisted of university researchers (from Harvard and the University of California). The third team worked for a start-up biotechnology firm called Genentech, backed by venture capital. After an intense competition, the race was won by Genentech, whose researchers successfully synthethized the human insulin gene in August 1978. Immediately after the validation of its research, Genentech applied for a patent on the invention and entered into an exclusive license agreement with Eli Lilly to cooperate in its further development (Gans and Stern, 2003).

Many new biotechnology firms (NBFs) employ this approach. An example is Canadian-based Virexx Medical, which specializes in therapeutic products to treat hepatitis, other infectious diseases, and tumors, invented a new ovarian cancer drug, OvaRex. Virexx. Under the terms of an exclusive license agreement with United Therapeutics, Virexx was responsible for developing the drug, and United Therapeutics for testing it in Phase III clinical trials (www.marketwire.com).

Another example is the Danish firm NeuroSearch, founded in 1989, which develops compounds to treat diseases of the central nervous system. As of this writing (July 2006), the company is working on seven potentially valuable drugs under exclusive licensing agreements with Glaxo Smith Kline, Abbott Laboratories, and TopoTarget, at stages in the development process ranging from the Preclinical Phase to Clinical Phase II (www.neurosearch.com).

(4) The *expansionary* strategy (market pull-high mutual dependence): Developing an invention in close cooperation with other firms and engaging in extensive reciprocal knowledge sharing and cross-licensing

Finally, in the *expansionary* strategy, the inventor enters into license agreements with numerous market participants (suppliers, competitors, customers), including cooperations with the producers of complementary assets, with the goal of rapidly diffusing the technology. Perhaps the best known example is ARM (Advanced RISC Machines) Holdings Plc., formed in 1990 by twelve Cambridge University engineers, which calls itself a purely intellectual property licensing company. ARM is the developer of RISC chips, microprocessors that enable computer hardware to interpret and carry out software commands. Its license partners are semiconductor companies, who add their own application-specific technology to the ARM technology, manufacture the chips in their wafer fabrication plants, and sell them to Original Equipment Manufacturers like Nokia or Hewlett Packard. In this way, the ARM design ends up in a vast range of consumer and industry products, from mobile phones to personal organizers to digital cameras. ARM generates revenue from widely licensing its chip designs, earning royalties on the products sold using these designs (O'Keeffe, 2002).

Two other examples might be mentioned. The first is Qualcomm, founded in 1985, produces handsets embodying its "code division multiple access" (CDMA) technology. Initially, the company provided contract research and development services, and engaged in limited product manufacturing for the wireless communications market. In the early 1990s, it introduced a wireless telephone technology, which embodied the CDMA technology into cellular phones (handsets). But Qualcomm soon realized there was greater competition in the product market for CDMA than in the market for the technology *per se*. It divested itself of manufacturing and concentrated on licensing CDMA (Arora *et al*., 2001, and http://www.qualcomm.com).

A final example is Cambridge Display Technologies (CDT), launched in 1992 as a Cambridge University spin-off specializing in the innovation of light-emitting polymers, which can be applied in a variety of products, including calculators, cellular phones and laptop computer screen displays. CDT soon became the global leader in this technology. But it lacked world

class capabilities to manufacture and market it. When CDT tried to do so, the company nearly went bankrupt. As a result, they changed the company's business model to focus solely on licensing out the technology. CDT entered into licensing and co-development and manufacturing deals with established manufacturers like Philips Electronics, Seiko-Epson, Hoechst and Du Pont, enabling its partners to apply their complementary skills to the technology to develop specific products for their markets (Arora *et al.*, 2001, http://www.cdtltd.co.uk).

4. Challenges and opportunities for IP vendors

IP firms face daunting challenges if they are to succeed in creating value from their inventions. For one thing, they are highly vulnerable to the uncertainties associated with the innovation process (e.g. Courtney *et al.*, 1997, Christensen, 1997, Rosenberg, 1995). One type of uncertainty has to do with the market for the new good. What will the future demand be? A particular problem for IP vendors is that as suppliers in the market for ideas, they can face conflicting demands. Not only are buyers themselves uncertain as to the future demand for their products, but the invention may potentially appeal to different customer segments. How can IP vendors best handle feedback from different customers? Should they customize products for individual buyers, or not? Innovation is also characterized by technological uncertainties. Will the invention, after leaving the laboratory, be technically superior to existing products? Will it quickly be outdated? Again, as a purveyor of ideas, it can be especially difficult for the IP provider to know the value of its input into a buyer's future product line, particularly if it also has a short product life cycle.

To the degree that an IP firm enters into a joint development agreement with one buyer (Strategy 3), it is guaranteed a market for the invention, but it also locks itself into that buyer's needs, resource constraints, and future goals. If it seeks to please many buyers at the same time (Strategy 4), it secures the opportunity to create a huge market for its invention – but risks pleasing no-one. If it seeks to maintain its independence (Strategies 1 and 2), it retains technological flexibility, but risks never actually commercializing its inventions. Patent trolls, for example, gamble that another firm needs access to their technology. If other

firms do not infringe their patent, they get nothing (not even license royalties). Yet they stand to hit the jackpot if they succeed.

Since the costs of R&D are fixed (and typically sunk), IP vendors can leverage their patents to create a "hold-up" situation. This is particularly the case in industries where innovation is cumulative, since the vendor can exercise its patent claim against subsequent innovators, putting the potential licensee is at a considerable negotiation disadvantage (e.g. Bessen, 2004, Scotchmer, 1991). Patent troll contributors (Strategy 2) have been the most blatant in exploiting this opportunity, as was aptly illustrated by the recent court battle between NTP and RIM, the manufacturer of the BlackBerry series. The possibility of hold-up clearly also strengthens the position of IP vendors such as ARM, whose business model ties its own destiny intimately to that of its partners, creating a dense network of interrelationships. The logic here, however, is to create incentives on all sides to pursue "winning" designs.

The risk of hold-up arguably applies as well to IP vendors operating in non-cumulative industries. Potential licensees in the automobile industry, for example, may be reluctant to contract with IP providers for inventions in engine technology, where even a tiny components supplier might be in the position to act opportunistically. Monteverde and Teece (1982) showed that the greater the degree of asset specificity in transactions governing automobile components (and thus the higher the expected appropriable quasi-rents), the greater the tendency towards the vertical integration. Klein, Crawford and Alchian (1978) showed this empirically in their analysis of General Motor's decision to buy out Fisher Body in the 1920s.

The possibility of hold-up can help to explain why Orbital Engine Corporation failed to license out its environmentally friendly engine technology – and clarify the core dilemma faced by this company. OEC's policy of non-exclusive licensing, combined with maintaining tight control over its property rights, ensured that the basic idea would not be appropriated. But it may also have guaranteed that the technology would never be commercially adopted by any one manufacturer, let alone the automobile industry as a whole. We will return to the implications of this dilemma in the next section.

IP vendors must continuously juggle the desires of their customers with their own technical skills and capabilities, a problem not made easier if combined with the need to serve many different buyers. If the buyer miscalculates, for example, the supplier in the market for ideas may get stuck with an old, outdated technology, missing the opportunity to establish itself in a new market. A related problem is the "not invented here" syndrome. Even when an established firm licenses the rights to an invention, its R&D staff may lack interest in further developing it, since the invention does not fit into their current programs and future plans. These problems are the most acute for IP vendors that choose Strategies 1 and 2.

Moreover, should the physical embodiment of the idea become outdated, the underlying idea may remain viable, providing the basis for an improved product. A manufacturer can in this way continue to "reuse" existing inventions in new manifestations. An IP vendor, by contrast, is dependent on generating value from the idea itself. Once an idea has been licensed out, the IP vendor must come up with a patentable improvement to the original idea, or a completely new idea, or go out of business.

Among the potential contractual hazards (e.g. Pisano, 1990, Williamson, 1996) faced by an IP vendor is that the buyer might appropriate part of the value of its proprietary knowledge without paying for it, a problem first described by Arrow (1962). The value of an idea is initially dependent on its not being known to others. But to realize the value of that idea, the innovator must disclose it, at least in part. Given the public good nature of information, and lacking effective legal protection, as soon as the seller reveals the idea, both the buyer and the seller possess it, reducing the seller's bargaining power, since the buyer may now see no reason to pay the seller for the rights to the idea.

A seller on the market for ideas is arguably particularly vulnerable, being based solely on knowledge creation. *Ceteris paribus*, if new knowledge can be embodied in physical form, it will be easier for an innovator to secure appropriability. The innovator can produce and sell the physical embodiment of the idea, while keeping the underlying knowledge secret. A physical product with a relatively high degree of complexity can be difficult to imitate, requiring specialized knowledge, while the basic idea may be more easily be grasped.

These appropriability hazards can be illustrated by the story of the inventor Robert Kearns, who in the early 1960s patented the intermittent windshield wiper. Since Kearns was unable to commercialize this invention on his own, he presented the idea to Ford Motor Company, disclosing to senior engineers not only the operating principles, but also the functionality of his invention. Ford ultimately rejected Kearns' license proposal. Shortly thereafter, Ford began to feature a similar technology in its automobiles. Kearns objected that they had copied his idea. But for over twenty years, neither Ford nor other automakers paid Kearns royalties on this invention. Finally, in the 1990s, the courts successfully upheld his patent, enabling him to extract a portion of the economic returns for himself (Gans and Stern, 2003).

On the other hand, most knowledge is context specific. According to the literature on absorptive capacity (Cohen & Levinthal, 1989), having access to new knowledge is not the same as the ability to use it productively. The innovator's R&D lab must be able to assimilate and exploit the information in a productive way. Information may also be "sticky," to the degree that it is costly to transfer from one place to another (Von Hippel, 1994). Similarly, as Boldrin and Levine (2006) point out, despite suggestions in the economic literature that ideas are subject to "spillover externalities" or informational leakage, this occurs very seldom in practice. All ideas, they argue, are costly and time-consuming to reproduce.

For IP vendors, this raises the question of how best both to secure appropriability and promote knowledge transfer. To survive and prosper, they must earn license revenues. That strong intellectual property protection facilitates the creation and organization of markets for ideas (e.g. Arora and Merges, 2005, Gans and Stern, 2003) is evidenced by Orbital Engine Corporation's aggressive patenting strategy and reluctance to grant an exclusive license to any one automobile manufacturer. But the knowledge generated in a vendor's own R&D programs may not easily be transferable. This dilemma might tend to "favor" those vendors that pursue Strategies 3 and 4 (where knowledge-sharing with customers occurs from the beginning, and is regulated through the license agreement), and make it more difficult for those that prefer Strategies 1 and 2 (where knowledge-sharing occurs after the invention has been made).

Certain technologies are easier to transfer than others. Ultra-Scan's fingerprint technology, for example, has been sufficiently developed so as to be ready for use, and the range of potential

buyers is considerable. By contrast, NeuroSearch's compounds can only by utilized by pharmaceutical corporations specializing in the same markets. As a result, the number of potential buyers for NeuroSearch (and other biotech vendors) is limited, not only due to the ease of transfer of the technology *per se*, but also the size of the potential market.

Appropriability problems will play out somewhat differently, depending on which strategy the IP vendor pursues. For visionary IP providers, what matters most is to retain proprietary control during the inventive process, licensing out the rights only when the vendor has reached the point when it can do no more. Knowledge-sharing is not central to the business models of IP vendors, though it may occur. For IP providers that pursue the directed or the expansionary strategies, reciprocal knowledge-sharing is critical to the license relationship. For example, whenever ARM grants a license, it tries to build a reciprocal relationship giving ARM insights into the license partner's process technology, and access to new knowledge about emerging applications. This helps ARM design chips that best fit its partners' future technologies and application needs. The more end applications that can be serviced by an ARM chip, the more both ARM and its partners can earn. Finally, for trolls, what matters is whether or not the defendant believes that their patents may be valid, as illustrated by the RIM case, where the validity of NTP's patents was never ascertained.

Other contractual problems are related to information asymmetry. Unless the IP vendor can convince the buyer of the superiority of the idea, it will find it difficult to command a high compensation. IP vendors may incur substantial costs of identifying and negotiating with suitable partners. Once they have licensed out the invention, they become dependent on the buyer to commercialize it. But the licensee may be unable, or perhaps unwilling, to give priority to the invention. Or it might adopt a losing marketing strategy. After the license is signed, the licensee might use the invention to create value for itself in a way not agreeable to the IP vendor (Davis, 2001, Kultti and Takalo, 2002). Alternatively, the licensee might buy the rights to the invention not to commercialise the product, but to prevent another firm from acquiring those rights. This problem is described in Thursby (2005), who analyzes the risk that a licensee might shelve an invention by a university researcher, and what contractual solutions exist. This logic can readily be extended to IP firms.

For most IP providers, information asymmetry is a disadvantage, though for somewhat different reasons. Both *ex ante* and *ex post* information asymmetry complicate the negotiating process for vendors that pursue Strategy 3, since the invention has not yet been developed. The buyer faces the problem of selecting the best supplier (adverse selection), and ensuring that the supplier does what has been agreed without being able to directly observe it (moral hazard). The two parties become locked into each other through the exclusive license contract, making it crucial to align the incentive structures of the two parties.

Ex ante asymmetric information is less of a problem for buyers contracting with "visionary" IP vendors, since the licensor has already demonstrated its capabilities. All the buyer needs to assess is the value of the invention itself, as well as the chances that the vendor will continue to perform as expected. In the expansionary strategy, problems of asymmetric information are to a certain extent ameliorated because the seller hopes to diffuse the invention as widely as possible (and therefore seeks to disseminate information about its capabilities as well). But in both cases, clearly, moral hazard can impose costs after the contract has been signed. The only sub-group of IP vendors who benefit from information asymmetry are the trolls, since it is in their interests that would-be infringers initially are not aware of their patents.

5. What is "commercial success" for an IP vendor?

The companies we have discussed have in many respects done well. By 2001, for example, ARM Holdings had achieved a market share of 77% of the embedded RISC processor market, and become accepted by industry leaders as the *de facto* global standard. In 2006, it reported a more than 28% increase in first-quarter profit, reflecting a surge in royalty revenues from devices incorporating its chips (O'Keeffe, 2002, Palmer, 2006, www.arm.com). In 2005, Cambridge Display Technologies employed 123 people and reported sales of $18.1 million (Hoovers Company Record, Fact Sheet, 2006). Qualcomm's license revenues were expected to reach $2.6 billion in 2006 (*Financial Times*, May 12, 2006).

But "success" may be elusive. Thus Orbital Engine Corporation, established in 1970, had by 1992 concluded seventeen agreements (license options, licenses, and joint ventures) based on its fuel injection technology, and earned over A$110 million (cumulatively) from the sale of

its intellectual property. OEC generated so much income from royalties on its test engines and provisional licenses that it had become the largest company in Western Australia in terms of market capitalization by 1990, and was hailed as the best performer on the Australian stock market. Subsequently, OEC found new outlets for its fuel injection process in engines for motorcycles, motorboats, and lawnmowers. In 2004, the company employed ninety-three people, and listed sales of $11.6 million, mainly from its license agreements, along with prototype and component manufacturing (Hoover's Company Record, Fact Sheet, 2006). Nevertheless, as of this writing, none of the company's license deals has led to the commercialisation of the fuel injection process in its main target market: automobile engines (http://www.orbeng.com.au). OEC's engineers, pursuing their visionary strategy, continued to refine and perfect a technology that automobile manufacturers ultimately did not incorporate into their vehicles, even as they continued to pay license fees for the rights to do so.

Also important is the systemic nature of technologies in vertically integrated, capital-intensive industries like automobiles, as mentioned in Section 4. A new invention's commercial development often depends on its compatibility with the demands of existing markets (Metcalfe and Gibbons, 1989, Rosenberg, 1995). No matter how good the invention is, it will only be valuable to potential buyers if it can be integrated into this larger system. OEC's fuel injection technology, while technically and environmentally superior to existing technologies, would involve revamping existing engine technology. Car dealers and insurance agents would have to learn about the new engine. Mechanics would have to be trained in its repair. Automobile manufacturers might not be completely certain about the safety and reliability of a technology developed by an IP provider. This could put them at risk for consumer lawsuits.

What other solutions might have worked for OEC? Not many, it turns out. The company's core competencies were in idea generation, not manufacture. Even if it had wished, it could not easily have become a manufacturer of automobiles, or even of engines. Should OEC originally have entered into an exclusive licensing arrangement with one automobile manufacturer? This might have facilitated commercialization – but it would also have required OEC to relinquish control over the wider implementation of the technology. OEC might also have feared that the licensee might not, in practice, ultimately have been committed to commercializing the idea.

By not having to build up big downstream manufacturing and marketing capabilities, IP providers can channel resources into continued new product development, and build up their core competencies in invention. This enables them to avoid the costs and risks of actual commercialization. They can learn from their customers about current and future market needs, promising new technologies, competitor positioning, and the like. IP vendors enjoy greater flexibility in exploring the potential of their ideas, while still maintaining control. They can enter different types of licensing arrangements, depending on the partner and the product concerned. If their inventions are attractive enough, they can use their IP as the basis to attract additional venture capital, and thereby continue to exist for a long time without actually producing anything. This raises several intriguing questions: How much should an IP vendor should diversify into new areas? How big should it grow? At what point does an ideas factory become too unwieldy?

The licensing choices of IP vendors can also change over time. For example, ARM Holdings started out as a university spin-off, and its very early licensing strategies would probably best be characterized as Strategy 1. But as the company grew in size and experience, it began to move towards a more ambitious goal: to set the international standard for RISC processors, Strategy 4. Similarly, many university spin-offs specializing in medical biotechnology start off using Strategy 1 (where the invention stems from their academic research). But if the invention shows commercial promise, they typically move on to Strategy 3, entering into licensing agreements with a pharmaceutical corporation. How companies combine licensing strategies, change licensing strategies, or abandon their IP licensing business model, could all provide fruitful areas of inquiry in the future.

IP vendors can also change their business models. IP vendors can integrate into both upstream and downstream operations. Genentech, for example, now also engages in production and commercialization (http://www.gene.com). Systemonic experienced difficulties in demonstrating the value of its intellectual property shortly after its establishment, and became a semiconductor manufacturer (Campbell, 2000). What factors lead to these changes? IP vendors may also become targets for acquisition (Christensen *et al.*, 2005). Systemonic, for example, was acquired by Philips in 2003 (www.philips.com).

Finally, the line between IP vendors and manufacturers may be blurred. Consider the case of the California-based Burst.com, whose founder, Richard Lang, patented a method for transmitting data over digital networks. By the late 1990s, his company employed over a hundred people to sell a software package called Burstware. But in 2000, Microsoft upgraded its Media Player software, with the result that Burst's software stopped working. Burst nearly went bankrupt – and resolved to fight back (thus adopting a "troll" strategy). After considerable effort, Lang was able to obtain financial backing to pursue a lawsuit against Microsoft. In March, 2005, Microsoft agreed to pay Lang $60 million in a settlement that did not involve the software giant admitting liability (Burrows, 2006). Was Burst.com forced to pursue a troll strategy, or had it been hoping to do so all along? Can its $60 million award from Microsoft be seen as a sign of its success (as a troll), or failure (as a software producer)?

6. Conclusion

IP providers stand to earn considerable sums from their royalty agreements. But they are also more exposed, since if they cannot license out the rights to their ideas, they have no basis to exist. Sharing knowledge enhances learning, but also raises the hazard of expropriation of proprietary knowledge. IP vendors risk being bought up by larger companies on the "market for ideas". They are dependent on their customers for their ability to survive into the future. But this very dependence may mean that they become too locked in to past technologies. Each of the four licensing strategies described above provide a different means by which to address these trade-offs, with greater or lesser degrees of success.

While IP firms have in common their need to generating value from knowledge, they differ in a number of other respects. Some, like NTP, are very small, consisting of just one or a few employees. Others, like ARM, employ thousands of people. Some seek to retain their independence from their buyers, others are eager to cooperate closely with buyers. Some leverage licenses simply to transfer the rights to the buyer, others use them to provide the legal basis for knowledge sharing and cooperative development.

Further research could address several issues raised in the paper but not pursued in any depth. First, the four strategies identified in Section 3 overlap to a certain degree, making it difficult to draw the line between them. Moreover, while our IP providers have, for the sake of clarity, been classified according to their licensing strategies, these firms may well pursue several different licensing strategies, depending on the nature of their inventions. In addition, in our discussion of the factors affecting licensing choices, we did not systematically explore why some IP vendors choose exclusive licenses, and others non-exclusive licenses? Why do some license out individual inventions, and others portfolios of inventions? Under what circumstances are license options employed? Future studies could examine what it is that makes certain IP vendors attractive targets for takeover.

More work is also needed on how IP providers' licensing strategies differ according to the sector in which they operate. To a large degree, the licensing strategies outlined above are industry-specific. Strategy 2 firms seem to be limited to the software and electronics industries. The only examples of the directed strategy that I have been able to find specialize in the area of biotechnology, and the only illustrations of the expansionary strategy are in electronics (either firms that work in this field or supply inventions to firms in this industry). Only for Strategy 1 are firms from a variety of industries represented. For example, what, more specifically, about the biotechnology industry, leads firms to pursue Strategy 3? Why do firms in other industries never (as far as I can determine) choose this strategy?

A final area for future research could be to explore the policy implications of the findings in this paper. It is frequently stated that the ability to leverage knowledge strategically is central to competitive advantage in today's economy. IP providers would seem to provide a cheap way for society to expand the sum total of ideas potentially available for commercial exploitation, since they generate ideas without the costs of development (though they, and society more generally, are dependent on the willingness and ability of others to develop them). Should countries deliberately try to foster IP firms? What would be required to increase their chances of success? What special problems should be addressed?

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REFERENCES

Arora, A. (1995). "Licensing tacit knowledge: Intellectual property rights and the market of know-how," *Economics of Innovation and New Technology,* Vol. 4, pp. 41-79.

Arora, A. and Fosfuri, A. (2003). "Licensing the market for technology," *Journal of Economic Behavior & Organization*, 52, pp. 277-295.

Arora, A., Fosfuri, A. and Gambardella, A. (2001). "Markets for technology and their implications for corporate strategy," *Industrial and Corporate Change*, 10 (2), pp. 419-451.

Arora, A. and Merges, R.P. (2004). "Specialized supply firms, property rights and firm boundaries," *Industrial and Corporate Change* 13 (3), pp. 451-475.

Arrow, K.A. (1962): 'Economic welfare and the allocation of resources for invention.' *The Rate and Direction of Inventive Activity: Economic and Social Factors.* Conference No. 13, Universities-National Bureau of Economic Research. Princeton: Princeton University Press.

Atuahene-Gima, K. (1992). "Inward technology licensing as an alternative to internal R&D in new product development: a conceptual framework," *The Journal of Product Innovation Management*, June, 9 (2), pp. 156-167.

Bessen, J.B. (2004). "Holdup and licensing of cumulative innovations with private information," *Economics Letters*, 82 (3), pp. 321-326.

Bessy, C., Brousseau, E and Saussier, S. (2002). "The diversity of technology licensing agreements." Unpublished paper, June, 30 pp.

Boldrin, M. and Levine, D.K. (2006). "Globalisation, intellectual property, and economic prosperity," *Spanish Economic Review*, 8, pp. 23-24.

Breschi, S., Malerba, F. and Orsenigo, L. (2000). "Technological regimes and Schumpeterian patterns of innovation," *Economic Journal* 110, pp. 388-410.

Burrows, P. (2006). "Underdog or patent troll?" *Business Week*, April 24, Issue 3981, p. 58.

Campbell, K. (2000). "A chip spun off the US block: Venture capital: Katharine Campbell looks at a German university's pioneering spin-off," *Financial Times*, December 7, p. 18.

Caves, R., Crookel, H and Killing, J.P. (1983). "The imperfect market for technology licensing," *Oxford Bulletin of Economics and Statistics*, 45 (3), pp. 249-267.

Choi, J.P. (2000). "Technology transfer with moral hazard," *International Journal of Industrial Organization*, 19, pp. 241-267.

Christensen, C.M. (1997). *The Innovator's Dilemma* (Cambridge, Harvard Business School Press.

Christensen, J.F., Olesen, M.H. and Kjær, J.S. (2005). "The industrial dynamics of open innovation - evidence from the transformation of consumer electronics," *Research Policy* 34 (10), pp. 1533-1548.

Coase, R.H. (1974). "The economics of the first amendment: the market for goods and the market for ideas," *American Economic Review* 64 (2), pp. 384-391.

Cohen, W. M., Nelson, R.R. and Walsh, J. P. (2000): *Protecting their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*. NBER Working Paper (Cambridge, Mass). 50 pages.

Cohen, W.M. and Levinthal, D.A. (1989). "Innovation and learning: the two faces of R&D," *Economic Journal* 99 (397), pp. 569-596.

Columbia, S.C. and Blasberg, S.L. (2006). "Beware patent trolls," *Risk Management Magazine*, April, 53 (4), pp. 22-27.

Contractor, F. (1981). *International Technology Licensing: Compensation, Costs, and Negotiation*. Lexington, Lexington Books.

Courtney, H., Kirkland, J and Viguerie, P. (1997). "Strategy under uncertainty," *Harvard Business Review*, November-December (12 p.)

Davis, L. (2006). "Patents and the Internet," in Eliasson, G. and Wihlborg, C., eds. *Law, Economics and Technology of the Internet* (Copenhagen: Copenhagen Business School Press). Forthcoming.

Davis, L. (2004). "Intellectual property rights, strategy and policy," *Economics of Innovation and New Technology* 13 (5), July, pp. 399-415.

Davis, L. (2001): 'R&D Investments, information and strategy,' *Technology Analysis and Strategic Management*, 13 (3), pp. 325-342.

Davis, L. and Davis, J. (2006). "Prizes as incentives: Reflections on a century of aviation contests," in Davis, J., Serin, G., Sundbo, J, and Gallina, A., eds. *Contemporary Management of Innovation: Are We Asking the Right Questions?* (London: Palgrave Macmillan).

Gambardella, A. (2005). "Patents and the division of innovative labor," *Industrial and Corporate Change* 14 (6), pp. 1223-1233.

Gambardella, A. (1995). *Science and Innovation - The US pharmaceutical industry during the 1980s*. Cambridge University Press.

Gans, J. S. and Stern, S. (2003). "The product market and the market for "ideas": commercialization strategies for technology entrepreneurs," *Research Policy* 32 (2), pp. 333-350.

Granstrand, O. (2000): 'The shift towards intellectual capitalism – the role of infocom technologies,' *Research Policy* 29, pp. 1061-1080.

Granstrand, O. (1999): *The Economics and Management of Intellectual Property*. Cheltenham, UK: Edward Elgar.

Grindley, P.C. and Teece, D.J. (1997). "Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics," *California Management Review*, 39 (2), pp. 8-41.

Guilhon, B., Attia, R. and Rizoulieres, R. (2004). "Markets for technology and firms' strategies: the case of the semiconductor industry," *International Journal of Technology Management*, 27 (2,3), pp. 123-142)

Hagedoorn, J. (2003). “Sharing intellectual property rights – an exploratory study of joint patenting amongst companies,” *Industrial and Corporate Change* 12 (5), pp. 1035-1050.

Hall, B.H. and Ham, R.M. (2001). “The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor Industry, 1979-1995,” *The Rand Journal of Economics*, 32 (1), Spring, pp. 101-128.

Heinzl, M. (2006). “BlackBerry case could spur patent-revision efforts,” *Wall Street Journal*, March 6, p. B4.

Klein, B., Crawford, R.A. and Alchian, A.A. (1978). “Vertical integration, appropriable rents, and the competitive contracting process,” *Journal of Law and Economics*, 21, pp. 297-326.

Klevorick, A.K. *et al*: (1995). “On the sources and significance of inter-industry differences in technological opportunities”. *Research Policy* 24, pp. 185-205.

Kollmer, H. and Dowling, M. (2004). “Licensing as a commercialisation strategy for new technology-based firms,” *Research Policy* 33 (8), pp. 1141-1151.

Kultti, K. and Takalo, T. “Hold-ups and asymmetric information in a technology transfer: the Micronas case,” *Journal of Technology Transfer*, 27 (3), June, pp. 233-243.

Larson, B.A. and Anderson, M. (1994). “Technology transfer, licensing contracts, and incentives for further innovation,” *American Journal of Agricultural Economics*, 76, pp. 547-556.

Leonard-Barton, D. (1992). “Core capabilities and core rigidities: A paradox in managing new product development, *Strategic Management Journal*, 13 (12 p.)

Macho-Stadler, I., Martinez-Giralt, X., Perez-Castrillo, D.J. (1996). “The role of information in licensing contract design,” *Research Policy* 25, pp. 43-57.

Malerba, F. & Orsenigo, L. (2002). "Innovation and market structure in the dynamics of the pharmaceutical industry and biotechnology: towards a history-friendly model,” Industrial and Corporate change, 11 (4), August, pp. 667-703.

Merges, R.P. and Nelson, R. R. (1994). “On limiting or encouraging rivalry in technical progress: the effect of patent scope decisions,” *Journal of Economic Behavior and Organization* 25 (1), pp. 1-24.

Metcalfe J. S. og Gibbons, M. (1989). "Technology, variety and organization: A systematic perspective on the competitive process" i Rosenbloom, R. S. og Burgelman, R. A.: *Research on Technological Innovation, Management and Policy*. London, pp 153 – 173.

Monteverde, K. and Teece, D.J. (1982). “Appropriable rents and quasi-vertical integration,” *Journal of Law and Economics*, 25, pp. 321-28.

Morkel, A. and Willoughby, K. (1992): *Orbital Engine Corporation.* Teaching Case.

Mowery, D.C. and Rosenberg, N. (1979). “The influence of market demand upon innovation: a critical review of some recent empirical studies,” *Research Policy* 3, pp. 220-242.

Nanayakkara, T. (2002). “Negotiating technology licensing agreements,” *International Trade Forum*, 4, p. 13.

Nuttall, C. and Waters, R. (2006) "BlackBerry dispute prompts calls for patents reform," *Financial Times*, March 6, p. 27.

O'Keeffe, E. (2002). *ARM Holdings Plc*. INSEAD-EAC, Singapore. Teaching case

Palmer, M. (2006). "Arm bolstered by royalty revenues," *Financial Times*, April 20, p. 21.

Pisano, G.P. (1990). "The R&D boundaries of the firm: an empirical analysis," *Administrative Science Quarterly*, March, 35 (1), pp. 153-176.

Puzzanghera, J. (2006). "EBay case before justices," *Knight Ridder Tribune Business News*, March 27, p. 1.

Rivette, K.G and Kline, D (2000): *Rembrandts in the Attic: Unlocking the Hidden Value of Patents* (Boston, Mass: Harvard University Press).

Rosenberg, N. (1995): Why technology forecasts often fail, *The Futurist*, July-August, pp. 17-21.

Scotchmer, S. (1991): 'Standing on the Shoulders of Giants: Cumulative Research and the Patent Law,' *Journal of Economic Perspectives*, Winter, 5 (1), pp. 29-41.

Soat, J. (2005). "EBay faces patent problems," *Information Week*, March 21, p. 1031.

Teece, D.J. (2000). *Managing Intellectual Capital* (Oxford, Oxford University Press).

Teece, D.J. (1998). "Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets," *California Management Review* 40 (3), pp. 55-79.

Teece, D.J. (1986): Profiting from technological innovation: implications for integration, collaboration, licensing and public policy, *Research Policy*, 15 (6). Reprinted in D.A. Teece, ed (1987), pp. 185-219.

Thursby, M. (2005). "Shirking, sharing risk and shelving: the role of university license contracts," *Paper presented to the Summer Conference of the Danish Research Unit for Industrial Dynamics*, Copenhagen, June 27-29. Available via the DRUID homepage, http://www.druid.dk).

Von Hippel, E. (1994). "Sticky information and the locus of problem solving: Implications for innovation". *Management Science* 40 (4), pp. 429-439.

Wappman, L.O. "Therex LLC, formed by UB inventors, to focus on drugs to combat infections, inflammatory diseases," University at Buffalo Reporter, 34 (1), available at http://www.buffalo.edu/reporter/vol34/vol34n1a/articles/Therex.html, accessed May 22, 2006.

Williams, F.O. (2002a). "Buffalo, N.Y., university spinoff licenses compound to pharmaceutical firm," *Knight Ridder Tribune Business News*, September 9, p. 1.

Williams, F.O. (2002b). "Amherst, N.Y-based Ultra-Scan considers IPO," *Knight Ridder Tribune Business News*, October 4, p. 1.

Williamson, O. (1996). *The Mechanism of Governance*, Oxford, Oxford University Press.

Williamson, O. (1991). "Comparative economic organization – the analysis of discrete structural alternatives," *Administrative Science Quarterly* 36 (4), pp. 269-296.

Williamson, O. (1985). *The Economic Institutions of Capitalism* (New York: Macmillan, the Free Press).

Yang, C., with Palmer, A.T. and Zegel, S.(2005). "The BlackBerry widow's tale," *Business Week*, December 19, 2005, p. 33.

Yoshikawa, T. (2003). "Technology development and acquisition strategy," *International Journal of Technology*, 25 (6,7), pp. 666-674.

Young, J.K. (2005). "The impact of firm and industry characteristics on technology licensing," *S.A.M. Advanced Management Journal*, Winter, 70 (1), pp. 42-49.

Anonymous articles:

"3G intellectual property," *Financial Times*, May 12, 2006, p. 16.

"P&G licenses its bottle simulation system," *Plastics Technology*, April, 2005, 51 (4), p. 25.

"One small step for space tourism…" *The Economist*, December 18th, 2004, pp. 141-142.

"Dead Patents Walking," IEEE Spectrum Careers, accessed at www.spectrum.ieee.org, July 4, 2006).

Home pages (all accessed in May, 2006)

http://www.arm.com
http://www.cdtltd.co.uk
http://www.gene.com
http://www.marketwire.com
http://www.neurosearch.com
http://www.orbeng.com.au
http://philips.com
http://www.qualcomm.com
http://www.scaled.com
http://ultra-scan.com
http://xprize.org

Hoover's Company Record, Fact Sheet (various companies)